

**WHAT IS CLAIMED IS:**

1        1.        An apparatus for the non-contact electrical test of electronic substrates comprising:  
2                at least one electronic substrate (20) having top surface conductive features (22) on a  
3        top side of said electronic substrate (20) in electrical contact with bottom surface conductive  
4        features (23) on a bottom side of said electronic substrate (20);  
5                an ionization source (10) positioned above said top surface of said electronic substrate  
6        (20) and connected to a first voltage source;  
7                a fixture holding said electronic substrate;  
8                an array of probes which contact said bottom surface conductive features;  
9                a second voltage source electrically connected to said array of probes to maintain said  
10        array of probes at virtual ground; and  
11                current measuring electronics in contact with said array of probes.

1        2.        The apparatus of claim 1 wherein said ionization source (10) is a conductive wire.

1        3.        The apparatus of claim 1 wherein said ionization source (10) is a mesh of conductive  
2        wires.

1        4.        The apparatus of claim 1 wherein said ionization source (10) is a conductive ribbon.

1        5.        The apparatus of claim 1 wherein said ionization source (10) is coated with  
2        molybdenum disulfide.

1        6.        The apparatus of claim 1 further comprising a shield (40) between said ionization  
2        source (10) and said top surface conductive features (22).

1        7.        The apparatus of claim 6 wherein said shield (40) has a cylindrical shape with an  
2        opening towards said top surface conductive features (22).

1        8.        The apparatus of claim 6 wherein said shield (40) is connected to a third voltage  
2        source.

1        9.        The apparatus of claim 6 wherein said shield (40) is segmented with each segment  
2        electrically insulated from each other and separately charged.

1        10.       The apparatus of claim 8 wherein said first voltage is approximately 5,000 volts, said  
2        second voltage is approximately ground and said third voltage is approximately 2,500 volts.

1        11.       The apparatus of claim 1 wherein said ionization source (10) is a positive ionization  
2        source.

1 12. The apparatus of claim 1 wherein said ionization source (10) is a negative ionization  
2 source.

1 13. The apparatus of claim 1 wherein said fixture (50) is comprised of a conductive  
2 material.

1 14. The apparatus of claim 1 wherein said fixture (50) has a tapered geometry.

1 15. The apparatus of claim 1 wherein said fixture (50) is connected to a fourth voltage  
2 source.

1 16. The apparatus of claim 15 wherein said fourth voltage has a value between said first  
2 voltage and said second voltage.

1 17. The apparatus of claim 15 wherein said fourth voltage is approximately ground.

1 18. The apparatus of claim 1 wherein said current measuring electronics are logarithmic  
2 amplifiers.

1 19. The apparatus of claim 18 wherein each of said logarithmic amplifiers are connected  
2 to said array of probes.

1 20. The apparatus of claim 18 further comprising circuitry connected to said array of  
2 probes to allow said current measuring electronics to be monitored individually with signals  
3 issued through a digital interface from a computer.

1 21. The apparatus of claim 20 further comprising an analog-to-digital converter to acquire  
2 and store measurements of the analog voltage level from said logarithmic amplifiers.

1 22. The apparatus of claim 18 wherein said logarithmic amplifiers are unipolar.

1 23. The apparatus of claim 18 wherein said logarithmic amplifiers are bipolar.

1 24. A method for the non-contact electrical opens test of electronic substrates comprising  
2 the steps of:

3 providing at least one electronic substrate (20) having top surface conductive features  
4 (22) on a top side of said electronic substrate (20) in electrical contact with bottom surface  
5 conductive features (23) on a bottom side of said electronic substrate (20);

5 securing said electronic substrate (20) in a fixture;

7 creating a region of ionized particles at an ionization source (10) positioned above

8 said top surface of said electronic substrate (20) by applying a first voltage to said ionization  
9 source;

0 exposing said top surface conductive features (22) to a cascade of said ionized  
1 particles by applying a second voltage to said bottom surface conductive features (23) and  
2 thereby creating an electric charge buildup on said top surface conductive features (22);

3 draining said charge buildup through said bottom surface conductive features (23) and  
4 creating a drain current into an array of probes in contact with said bottom surface conductive  
5 features (23); and

8 measuring said drain current with current measuring electronics in contact with said  
9 array of probes whereby any opens between a top surface conductive feature (22) and a  
0 bottom surface conductive feature (23) is detected by the absence of said drain current.

1 25. The method of claim 24 wherein said ionization source (10) is a conductive wire.

1 26. The method of claim 24 wherein said ionization source (10) is a mesh of conductive  
2 wires.

1 27. The method of claim 24 wherein said ionization source (10) is a conductive ribbon.

1 28. The method of claim 24 wherein said ionization source (10) is coated with  
2 molybdenum disulfide.

1        29.     The method of claim 24 further comprising the step of focusing said cascade of  
2        ionized particles by positioning a shield (40) between said ionization source (10) and said top  
3        surface conductive features (22).

1        30.     The method of claim 29 wherein said shield (40) has a cylindrical shape with an  
2        opening towards said top surface conductive features (22).

1        31.     The method of claim 29 further comprising the step of applying a third voltage to said  
2        shield (40).

1        32.     The method of claim 29 wherein said shield (40) is segmented, with each segment  
2        electrically insulated from each other and separately charged.

1        33.     The method of claim 31 wherein said first voltage is approximately 5,000 volts, said  
2        second voltage is approximately ground and said third voltage is approximately 2,500 volts.

1        34.     The method of claim 24 wherein said ionization source (10) is a positive ionization  
2        source.

1        35.     The method of claim 24 wherein said ionization source (10) is a negative ionization

1 36. The method of claim 24 further comprising the step of applying a fourth voltage to  
2 said fixture.

1 37. The method of claim 36 wherein said fourth voltage has a value between said first  
2 voltage and said second voltage.

1 38. The method of claim 36 wherein said fourth voltage is approximately ground.

1 39. The method of claim 24 wherein said current measuring electronics are logarithmic  
2 amplifiers.

1 40. The method of claim 39 further comprising the step of monitoring said array of probes  
2 individually with circuitry connected to said current measuring electronics which measure  
3 signals issued through a digital interface from a computer.

1 41. The method of claim 40 further comprising the step of storing measurements of the  
2 analog voltage level from said logarithmic amplifiers from an analog-to-digital converter.

1 42. The method of claim 39 wherein said logarithmic amplifiers are unipolar.

1        43.    The method of claim 39 wherein said logarithmic amplifiers are bipolar.

1        44.    A method for the non-contact electrical shorts test of electronic substrates comprising  
2        the steps of:

3                providing at least one electronic substrate (20) having top surface conductive features  
4        (22) on a top side of said electronic substrate (20) in electrical contact with bottom surface  
5        conductive features (23) on a bottom side of said electronic substrate (20);

6                securing said electronic substrate (20) in a fixture (50);

7                creating a region of ionized particles at an ionization source (10) positioned above  
8        said top surface of said electronic substrate (20) by applying a first voltage to said ionization  
9        source (10);

0                exposing said top surface conductive features (22) to a cascade of said ionized  
1        particles by applying a second voltage to said bottom surface conductive features (23) and  
2        thereby creating an electric charge buildup on said top surface conductive features (22);

3                draining said charge buildup through said bottom surface conductive features (23) and  
4        creating a drain current into an array of probes in contact with said bottom surface conductive  
5        features (23);

6                measuring said drain current with current measuring electronics in contact with said  
7        array of probes whereby any opens between a top surface conductive feature (22) and a  
8        bottom surface conductive feature (23) is detected by the absence of said drain current;



9 turning off said cascade of ionized particles;  
0 applying a different voltage bias on each individual probe in said array of probes; and  
1 re-measuring said array of probes with said current measuring electronics whereby any  
2 shorts are detected by a drain current.

1 45. The method of claim 44 further comprising the step of first measuring the voltage bias  
2 of each of said array of probes with no ionization source (10) and and no electronic substrate  
3 (20) in place to establish reference values for subsequent drain current measurements.

1 46. The method of claim 24 further comprising the step of first measuring the voltage bias  
2 of each of said array of probes with no ionization source (10) and and no electronic substrate  
3 (20) in place to establish reference values for subsequent drain current measurements.